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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/298,064	04/22/1999	GUANGCAI XING	2616-US/RTP/	1649

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EXAMINER

ZERVIGON, RUDY

ART UNIT	PAPER NUMBER
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1763

DATE MAILED: 04/17/2002

22

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.
09/298,064

Applicant(s)

Xing et al

Examiner

Rudy Zervigon

Art Unit

1763



-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136 (a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on Feb 26, 2002
- 2a) ☐ This action is FINAL.
- 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 35 C.D. 11; 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-7 and 17-20
- 4a) Of the above, claim(s) _____ is/are pending in the application.
- 5) ☐ Claim(s) _____ is/are withdrawn from consideration.
- 6) ☒ Claim(s) 1-7 and 17-20 is/are allowed.
- 7) ☐ Claim(s) _____ is/are rejected.
- 8) ☐ Claims _____ is/are objected to.
- _____ are subject to restriction and/or election requirements.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are objected to by the Examiner.
- 11) ☐ The proposed drawing correction filed on _____ is: a) ☐ approved b) ☐ disapproved.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

- 13) ☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).
- a) ☐ All b) ☐ Some* c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
 - ☐ Certified copies of the priority documents have been received in Application No. _____
 - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- *See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

Attachment(s)

- 15) ☐ Notice of References Cited (PTO-892)
- 16) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 17) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 17, 18
- 18) ☐ Interview Summary (PTO-413) Paper No(s) _____
- 19) ☐ Notice of Informal Patent Application (PTO-152)
- 20) ☐ Other

Application/Control Number: 09/298,064

Page 2

Art Unit: 1763

DETAILED ACTION

Request for Continued Examination

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on February 26, 2002 has been entered.

Art Unit: 1763

Claim Rejections - 35 USC § 102

2. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

3. Claims 1-4, 6, 7 are rejected under 35 U.S.C. 102(b) as being clearly anticipated by P. J. Matsuo et al¹. P. J. Matsuo et al identically describe a plasma semiconductor processing apparatus that generates a microwave plasma remotely relative to the substrate's location (Section I. Introduction; Figure 1). Additionally, the variable length of the plasma delivery tube is assessed under numerous conditions such as etch rates (Section III.A.2, p.1803), reaction layer thickness (Section III.C.4, p.1809), atomic (neutral) and reactive (radical) species concentration (Section IV.B, p.1812).

Specifically, and to further illustrate the teachings of P. J. Matsuo et al, the researchers describe:

- i. a first reaction chamber ("downstream tubing/lining", Figure 1)
- ii. a gas source (fluoromethane, oxygen, nitrogen, Figure 1) coupled to the first reaction chamber to supply a nitrogen gas to the first reaction chamber
- iii. an excitation energy source ("applicator, 2.45GHz", Figure 1) coupled to the first reaction chamber to generate a nitrogen plasma comprising ions and radicals from the nitrogen gas
- iv. a second reaction chamber ("processing chamber", Fig.1) adapted to house a substrate at a site in the second reaction chamber

¹*J.Vac.Sci.Technol. A* **15**(4), Jul/Aug 1997

Art Unit: 1763

- v. wherein the first reaction chamber is coupled to the second reaction chamber and separated from the substrate site by a distance equivalent to the lifetime of the ions (Figure 4) at a plasma generation rate such that the radicals react with the substrate in a process conversion step (film deposition, Refer to Figure 10(d) and section C.1 - "At point (d) N₂ is injected once more and the reaction layer thickness increases again.")
- vi. the excitation energy source supplies energy having a microwave frequency to generate a plasma from the nitrogen gas (abstract, first sentence)
- vii. The dimensions of the first reaction chamber ("...as the distance from the plasma to the etching region is increased...") are configured such that substantially all of the ions generated by the nitrogen plasma are changed from an ionic state to a charge neutral state within the first reaction chamber (Section IV.B, p.1812) *Fig. 25*
- viii. An apparatus (Figure 1) for exposing a substrate to plasma, comprising a first reaction chamber ("downstream tubing/lining", Figure 1)
- ix. means for supplying a nitrogen gas (fluoromethane, oxygen, nitrogen, Figure 1) to the first reaction chamber
- x. means for generating a plasma from the nitrogen gas ("applicator, 2.45GHz", Figure 1)
- xi. the plasma comprising ions and radicals (definition of plasma)
- xii. a second reaction chamber ("processing chamber", Fig.1) having means for housing a substrate

Art Unit: 1763

- xiii. means for providing the plasma to the second reaction chamber substantially free of ions such that the radicals react with a substrate in a process conversion step (Section IV.B, p.1812)

Item 6.v. is implicitly taught according to Figure 4. As shown in Figure 4, there are non-zero etch rates up to 125cm of first reaction chamber lengths. As such, lifetime of the ions, up to and including these distances, are sufficiently long enough so “that the radicals react with the substrate in a process conversion step”.

4. Claims 17-20 are rejected under 35 U.S.C. 102(b) as being anticipated by Mehrdad M. Moslehi (USPat. 5,082,517). Mehrdad M. Moslehi identically describe a plasma semiconductor processing apparatus that generates a microwave plasma remotely relative to the substrate's location (column 1, lines 5-15). The control of the composition of neutral and reactive species, and it's importance to plasma processing, is taught by Mehrdad M. Moslehi (column 1, lines 46-68; column 2, lines 37-42; column 4, lines 9-14; column 12, lines 56-68). Specifically, Mehrdad M. Moslehi describes a process conversion (column 4, lines 55-60) system where:

- xiv. A system (Figure 1) for reacting a plasma with a substrate
- xv. a first chamber (20, Figure 1)
- xvi. a gas source (12, Figure 1) coupled to the first chamber comprising
- xvii. constituents (12, Figure 1) adapted to react with a substrate (48, Figure 1)

Art Unit: 1763

- xviii. an energy source coupled to the first chamber (38)
- xix. a second chamber (24) configured to house a substrate for processing
- xx. a system controller (40) configured to control the introduction of a gas from the gas source into the first chamber and to control the introduction of an energy from the energy source (column 5, lines 43-52)
- xxi. a memory coupled to the controller comprising a computer readable medium having a computer-readable program embodied therein for directing operation of the system (implicit; column 5, lines 43-52), the computer readable program comprising:
- xxii. instructions for controlling the gas source and the energy source (column 5, lines 43-52) to convert a portion of a gas supplied by the gas source into a plasma comprising plasma ions and radicals (column 4, lines 9-14; column 10, lines 55-60, definition of plasma) and to deliver the plasma to the second chamber substantially (column 4, lines 9-14; column 11, lines 54-63; column 1, lines 46-52) free of ions to react with a substrate in the second chamber in a process conversion step

Art Unit: 1763

Claim Rejections - 35 USC § 103

5. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

6. Claim 5 is rejected under 35 U.S.C. 103(a) as being unpatentable over P. J. Matsuo et al² as applied to claims 1-4, 6, and 7 above, and further in view of Yamazaki et al (USPat. 6,130,118). P. J. Matsuo et al identically describe a plasma semiconductor processing apparatus that generates a microwave plasma remotely relative to the substrate's location (Section I, Introduction; Figure 1). However, P. J. Matsuo et al does not describe a rapid thermal processing chamber as a second chamber.

Yamazaki et al describes a plasma reaction apparatus for film deposition (column2, lines 20-25). Specifically, Yamazaki et al describes a substrate housing rapid thermal processing (RTP) chamber (104, Figure 4; column 6, lines 9-15).

It would have been obvious to one of ordinary skill in the art at the time the invention was made to substitute the P. J. Matsuo et al second reaction chamber for the Yamazaki et al substrate housing rapid thermal processing (RTP) chamber.

²J.Vac.Sci.Technol. A **15**(4), Jul/Aug 1997

Application/Control Number: 09/298,064

Page 8

Art Unit: 1763

Motivation for substituting the P. J. Matsuo et al second reaction chamber for the Yamazaki et al substrate housing rapid thermal processing (RTP) chamber is drawn to the enhanced insulation and thermal conductivity of prepared films (column 6, lines 57-59).

Art Unit: 1763

Response to Arguments

7. Applicant's arguments filed February 26, 2002 have been fully considered but they are not persuasive.

8. With regards to Applicant's position that "Matsuo does not describe nitrogen radicals that react with a substrate in a film conversion step", is again, in the Examiner's opinion not a relevant argument in view of the apparatus claims as presently filed. In particular, it is well established that apparatus claims must be structurally distinguished from the prior art. See MPEP 2114. As such, arguments directed to the state of gas molecules and the reactivity of these molecules to enable a "film conversion step" is not an argument addressing structural differences between the present invention and the Matsuo apparatus as cited above. Further, for additional completeness, an inspired appreciation of the Matsuo reference does provide the context for those of ordinary skill where there is teaching and discussion for the state of gas molecules and the reactivity of these molecules to enable a "film conversion step" (see "Experimental Results").

9. With regards to the position where "...Matsuo does not describe an apparatus including a second reaction chamber adapted to house a substrate "for film formation processing", or coupling a first reaction chamber to a second reaction chamber with a substrate site separated by a distance equivalent to the lifetime of the ions at a plasma generation rate such that the radicals react with the substrate in a process conversion step."

Art Unit: 1763

It is again established, in the body of the 35 U.S.C. 102(b) rejection, that P. J. Matsuo et al teaches:

“

- xxiii. an apparatus (Figure 1)
- xxiv. including a second reaction chamber (housing “E/S Chuck”, Figure 1) adapted to house a substrate (atop “E/S Chuck”, Figure 1)
- xxv. “for film formation processing” - Section III.C.1 page 1805, left column. - “...indicates the formation of a progressively thicker modified layer on the unperturbed silicon...”, “The formation of another layer takes place now.”, “This suggests that the post-plasma effect is actually an increase in the reaction layer thickness.”.
- xxvi. coupling (“Downstream Tubing/ Lining”, Figure 1) a first reaction chamber (housing “E/S Chuck”, Figure 1) to a second reaction chamber (where plasma is formed in Figure 1 - “Applicator” region) with a substrate site separated by a distance equivalent to the lifetime of the ions at a plasma generation rate (“...as the distance from the plasma to the etching region is increased...” - Section IV.B, p.1812) such that the radicals react with the substrate in a process conversion step (film deposition, Refer to Figure 10(d) and section C.1 - “At point (d) N₂ is injected once more and the reaction layer thickness increases again.”).

“

- 10. With regards to the position that “...the distance between the first reaction chamber and the substrate site separated by the lifetime of the ions, the ions available at the contact site are minimized so that predominantly radicals are available for reaction with a substrate as described in the

Art Unit: 1763

application.” - P. J. Matsuo et al establishes the foundations for the relationship of charge and uncharged species in the plasma environment according to “The separation distance and design of the transport region encompass some important parameters. The separation distance, lining, and geometry play a *major* role in which *reactive* species survive and reach the processing chamber.” (Section III.A.2). As such, P. J. Matsuo et al establishes the relationship between “separation distance” to the reaction chamber and the influence on the distribution, or concentration, of “reactive species” which also implies unreactive species if, by material balance, species are either reactive or nonreactive (inert).

P. J. Matsuo et al also, as stated above, teaches “a nitrogen gas” as claimed in the discussion towards the end of Section III.A.2 and, in addition, in Section III.C.1 page 1805, left column.

11. With regards to Applicant’s position that “Matsuo teaches that zero separation is best between a plasma generator and an etch chamber when nitrogen supplementation is contemplated.” - The Examiner notes that Applicant has not provided a location in the Matsuo reference where such instruction is suggested. Further, that Matsuo teaches a variable distance between a plasma generator and an etch chamber when nitrogen supplementation is contemplated (see above) fully addresses a range of distances as would be variable under operating conditions for optimizing the stated objectives of Matsuo et al. See MPEP 2144.05.

12. That independent claim 6 and dependent claim 5 “does not describe an apparatus for film formation processing or means for providing a plasma from a nitrogen gas to a reaction chamber free of ions such that the radicals would react with a substrate in a film conversion step.” is again, in the

Art Unit: 1763

Examiner's opinion not an accurate position with respect to a complete characterization of the Matsuo reference. In particular, Matsuo does teach an apparatus (Figure 1) capable of film formation processing (film deposition, Refer to Figure 10(d) and section C.1 - "At point (d) N₂ is injected once more and the reaction layer thickness increases again.") and means (detailed in the above rejections) for providing a plasma from a nitrogen gas to a reaction chamber with control of ion and radical concentrations ("4. Transport tube length effects", p. 1809; "B. Tube length", p.1812; "2. Etch rates versus tube length", p.1803) such that the radicals would react with a substrate in a film conversion step.

13. The Examiner's opinion with respect to "Moslehi does not describe a system including a first chamber and a second chamber wherein the first reaction chamber is separated from the second reaction chamber by a distance suitable to deliver a plasma to the second reaction chamber substantially free of ions to react with a substrate in a film conversion step", remains unchanged, and Applicant is again directed to the claim rejections above. Specifically Moslehi is applied to meet these stated claim requirements wherein Moslehi identically teaches system including a first chamber (20, Figure 1) and a second chamber (24) substantially wherein the first reaction chamber is separated (Figure 1) from the second reaction chamber by a distance suitable to deliver a plasma to the second reaction chamber substantially free of ions to react with a substrate in a film conversion step is provided by instructions for controlling the gas source and the energy source (column 5, lines 43-52) to convert a portion of a gas supplied by the gas source into a plasma comprising plasma ions and radicals (column 4, lines 9-14; column 10, lines 55-60, definition of plasma) and to deliver the

Application/Control Number: 09/298,064

Page 13

Art Unit: 1763

plasma to the second chamber substantially (column 4, lines 9-14; column 11, lines 54-63; column 1, lines 46-52) free of ions to react with a substrate in the second chamber in a process conversion step. As such, Moslehi provides apparatus teaching for controlling/influencing plasma constituent concentrations.

Application/Control Number: 09/298,064

Page 14

Art Unit: 1763

Conclusion

14. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Examiner Rudy Zervigon whose telephone number is (703) 305-1351. The examiner can normally be reached on a Monday through Thursday schedule from 8am through 7pm. The official after final fax phone number for the 1763 art unit is (703) 872-9311. The official before final fax phone number for the 1763 art unit is (703) 872-9310. Any Inquiry of a general nature or relating to the status of this application or proceeding should be directed to the Chemical and Materials Engineering art unit receptionist at (703) 308-0661. If the examiner can not be reached please contact the examiner's supervisor, Gregory L. Mills, at (703) 308-1633.

Plasma density

Plasma distribution

Tube length


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